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U. S. NAVAL AIR DEVELOPMENT CENTER

JOHNSVILLE, PENNSYLVANIA

Anti-Submarine Warfare Laboratory

REPORT NO. NADC-AW-6229 8 JAN 1963

RESEARCH AND DEVELOPMENT PROGRAM FOR AIRBORNE TOWED VEHICLES

PHASE REPORT
WEPTASK NO. RUDC4B000/2021/F001-06-01
Problem No. 303

SUMMARY

A phase I instrumentation system was developed to determine the dynamic flight characteristics of MAD airborne towed vehicles. Flight tests were performed employing the most recently modified towed vehicle, improved to house the AN/ASQ-46 MAD set.

The flight tests established that the angular accelerations, measured by the phase I instrumentation system, did not require a dynamic response beyond the stabilization capability of the magnetometer servo system. The static pressure variations measured at the aircraft were in close agreement with those recorded at the towed vehicle. This fact indicates that the ability of the towed vehicle to follow the aircraft motion is excellent.

An analytical study revealed that at a velocity of 150 knots and a tow cable length of 250 ft the towed vehicle should fly in a stable manner.

Further flight testing should determine the degree of correspondence between measured static pressure variations and actual altitude variations.

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Ref: (a) BUWEPS Conf ltr RUDC-44 ser 03382 of 26 Sep 1961
(b) Princeton University Report No. 603, "Report on the Stability of Airborne Towed Vehicles," of May 1962

INTRODUCTION

WEPTASK No RUDC4B000/2021/F001-06-01, Problem No. 303 was established by reference (a) for the development, test, and evaluation of new techniques to improve the range of Magnetic Anomaly Detectors (MAD). As part of the WEPTASK, a two-fold program was initiated at the Naval Air Development Center (NAVAIRDEVCEN) to evaluate and improve the current airborne towed vehicles employed to house the magnetometers. This program consists of extensive flight testing in conjunction with an analytical study of the towed vehicle stability problem.

DESCRIPTION

The phase I instrumentation system shown in figure 1 was developed to determine the dynamic flight characteristics of the current towed vehicles. The instrumentation system consists of a basic frequency-modulated telemetry system that transmits information from the towed vehicle to the towing aircraft.

The telemetry system consists of the conventional transducer, subcarrier oscillator, and mixer-amplifier components installed in the towed vehicle plus discriminators installed in the aircraft. Provision is made for preflight, inflight, and postflight calibration of the instrumentation system.

OPERATION OF EQUIPMENT

The multiplexed signals are received from the mixer-amplifier, transmitted through the tow cable, and recorded on magnetic tape in the towing aircraft. The signals are also sent to the oscillograph recorder portion of the system for a direct readout in the aircraft.

FLIGHT TEST EVALUATION

Using the phase I instrumentation system, static pressure variations were measured simultaneously at an AN/ASQ-46 towed vehicle and at the aircraft. Angular accelerations about the Y-axis and Z-axis were measured at the towed vehicle.

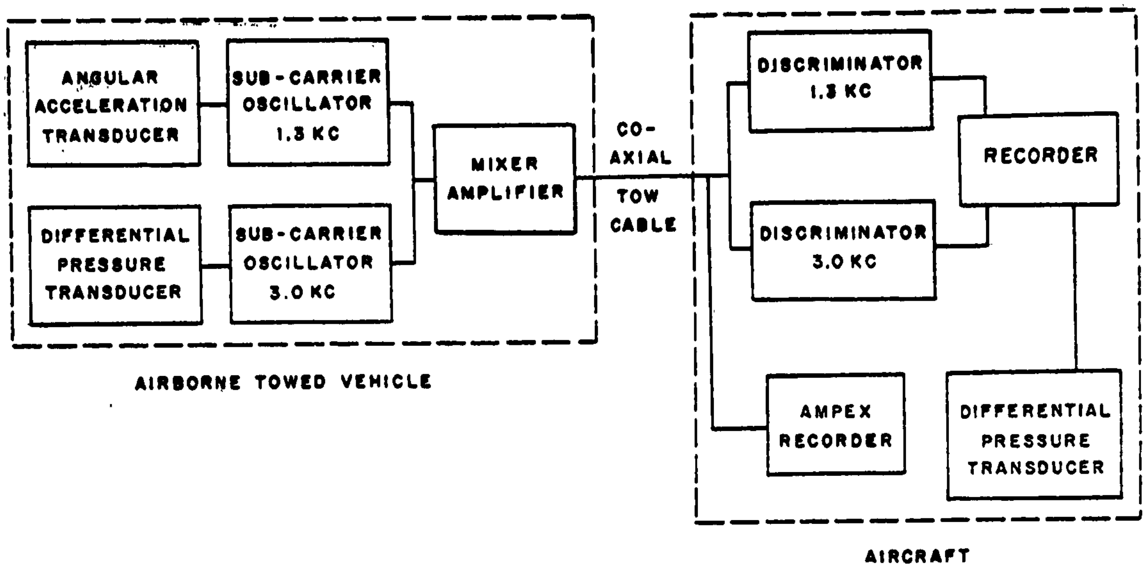

FIGURE 1 - Block Diagram. Phase I Instrumentation System

A typical oscillograph record of the aircraft and the towed vehicle pressure variations is shown in figure 2 for presumed straight and level flight. Figure 3 shows a typical record of aircraft and towed vehicle pressure variations for an incremental increase in aircraft altitude of 50 feet.

The flight test oscillograph records indicate that the towed vehicle follows the vertical displacement of the aircraft exceptionally well with a lag of approximately 0.5 seconds. Pressure variation peaks of the towed vehicle were more rounded than those recorded from the airplane. The differences in the sharpness of the peaks may be attributed to either the difference in dynamic characteristics of the differential pressure transducers or differences in the aerodynamic characteristics of the towed vehicle and the aircraft. Further laboratory experiments with the transducers and future flights with the towed vehicle pressure variations recorded should reveal the source of the observed differences.

The Y-axis angular acceleration had peaks of ±0.9 radians per second squared with a frequency of approximately 3 cps. A fine structure angular acceleration of ±0.3 radians per second squared at frequencies of 25 to 30 cps was superimposed on the gross angular acceleration of 3 cps. The Z-axis angular acceleration had peaks of ±0.6 radians per second squared with a frequency of approximately 2 cps.

The results of the flight test program were utilized in the analytical investigation conducted by Princeton University.

THE ANALYTICAL STUDY

The study, recently completed under Contract N62269-1369, had for its major purpose an improved comprehension of the dynamics of airborne towed vehicles. In reference (b), equations of motion were developed. Parameters considered were: the aircraft, the towing cable, and the towed vehicle. Because of the extreme complexity of the dynamic situation, certain simplifying assumptions were made. Analysis showed that errors caused by these simplifications were negligible.

A complete analysis of the tow cable dynamics is included in the study which reveals that the tow cable moves slowly from one equilibrium shape to the next while the towed vehicle moves dynamically. The longitudinal and lateral directional dynamics were studied separately and together. The important parameters that affected the stability of the vehicle were isolated. For a velocity of 150 knots at sea level and a tow cable length of 250 ft, the computed results are presented as plots of the lateral and longitudinal stability boundaries in figures 4 to 7. Referred to these boundaries, the aerodynamic performance of the AN/ASQ-46 towed vehicle was well within the stable region. Further theoretical study should reveal the towed vehicle characteristics required for stable behavior over a wide speed range.

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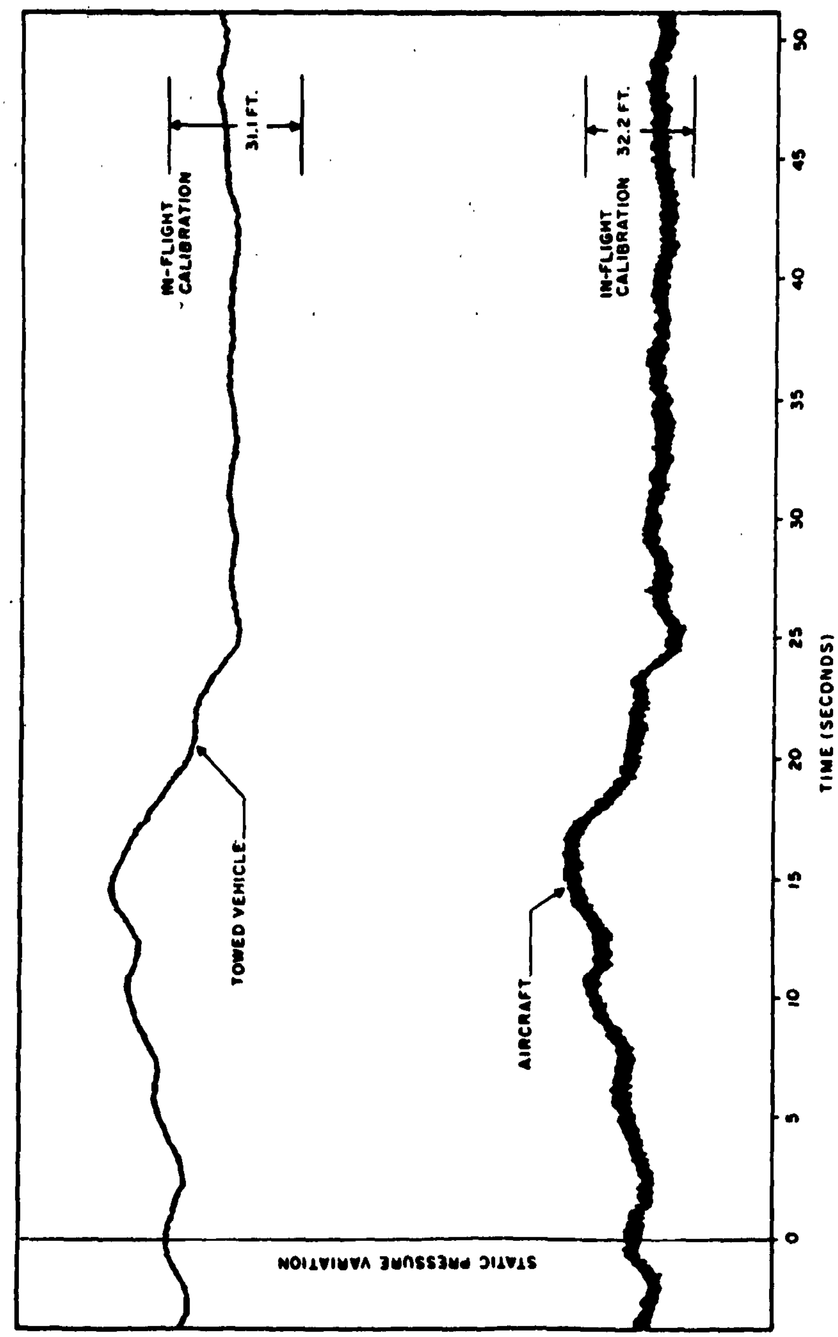

FIGURE 2 - Static Pressure Variations for Straight and Level Flight

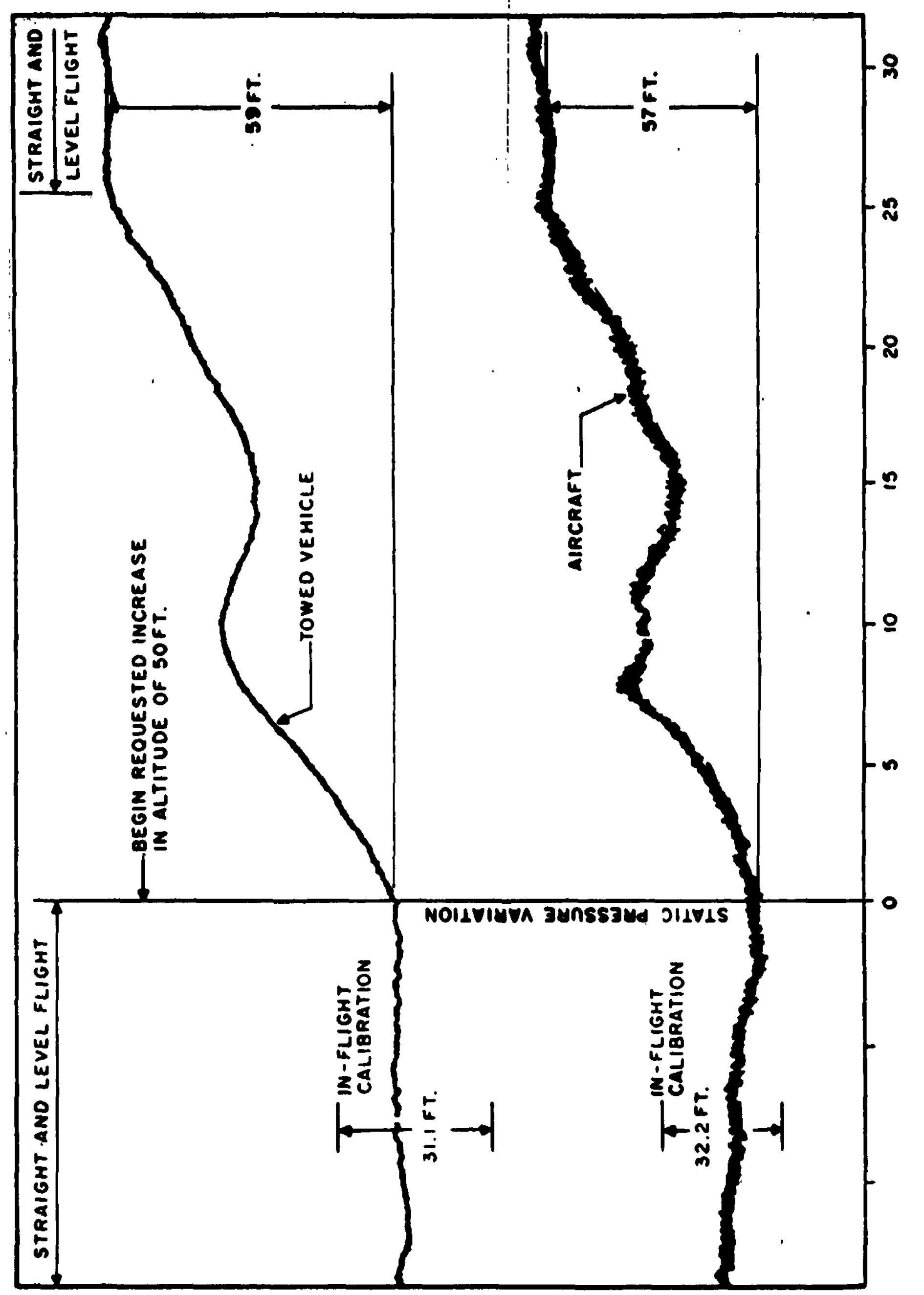

FIGURE 3 - Static Pressure Variations for an Increase in Aircraft Altitude of 50 Feet

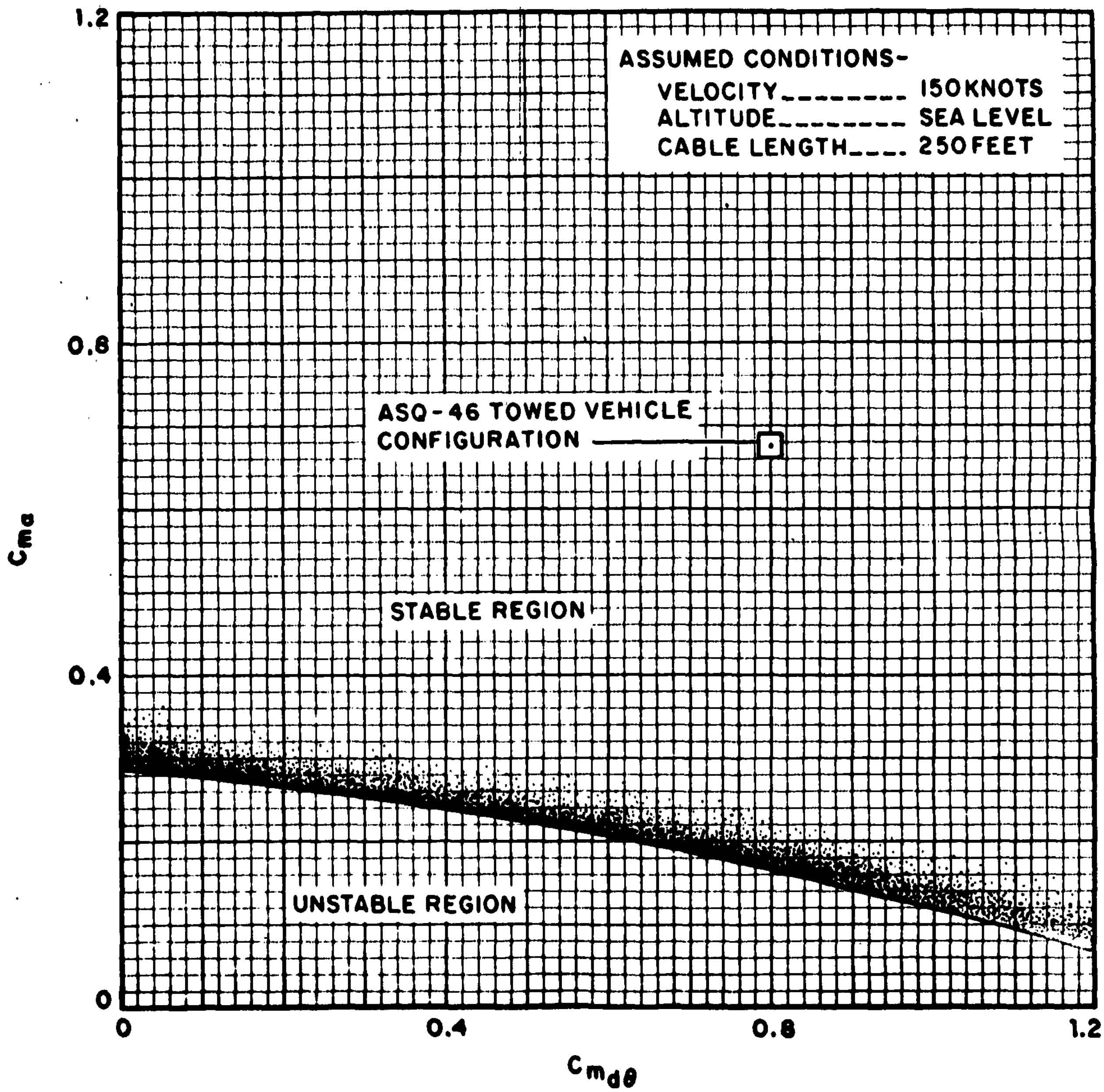

FIGURE 4 - Longitudinal Stability Boundary (C_{m_α} vs $C_{m_{d\theta}}$)

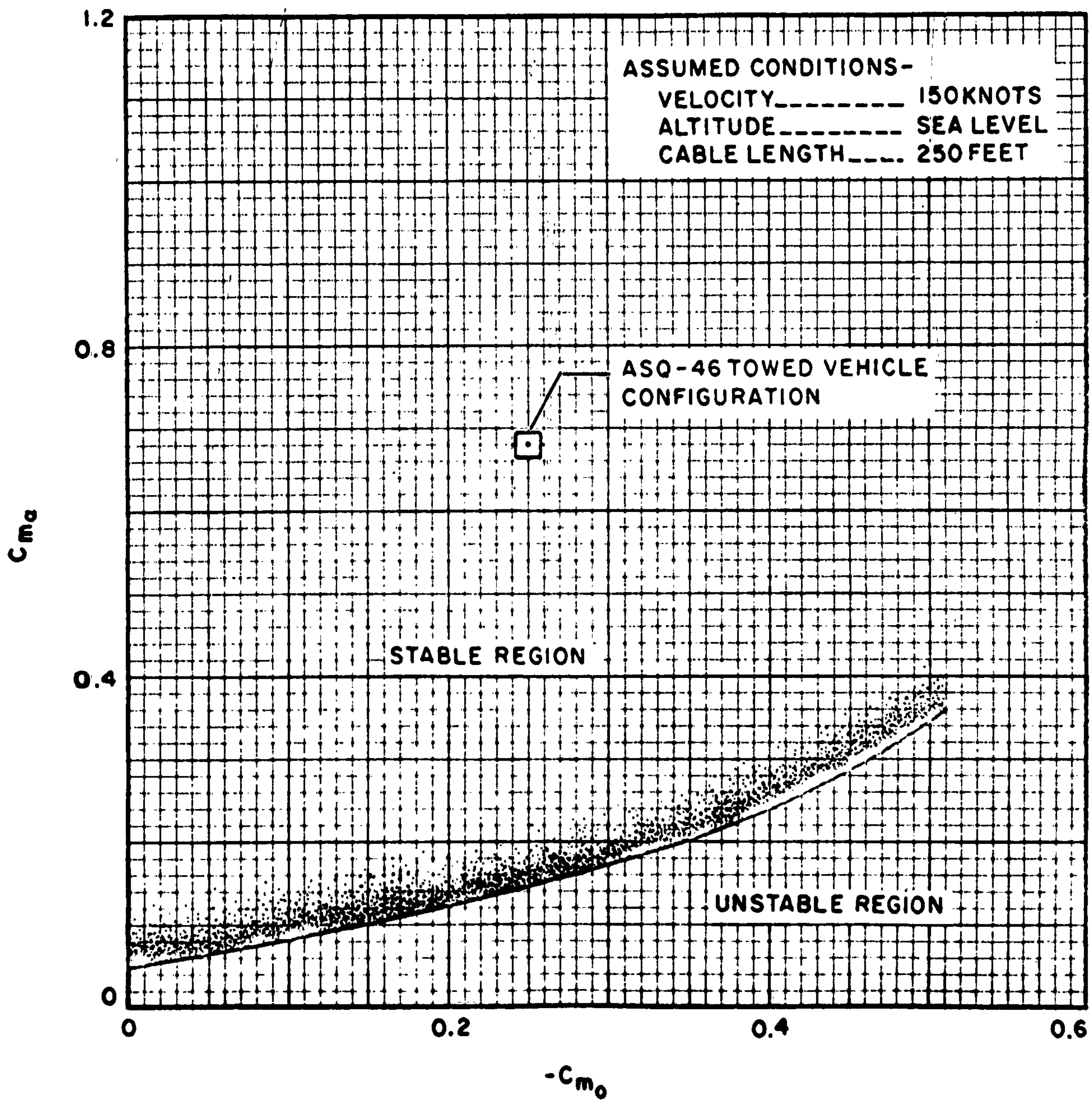

FIGURE 5 - Longitudinal Stability Boundary (C_{m_α} vs C_{m_o})

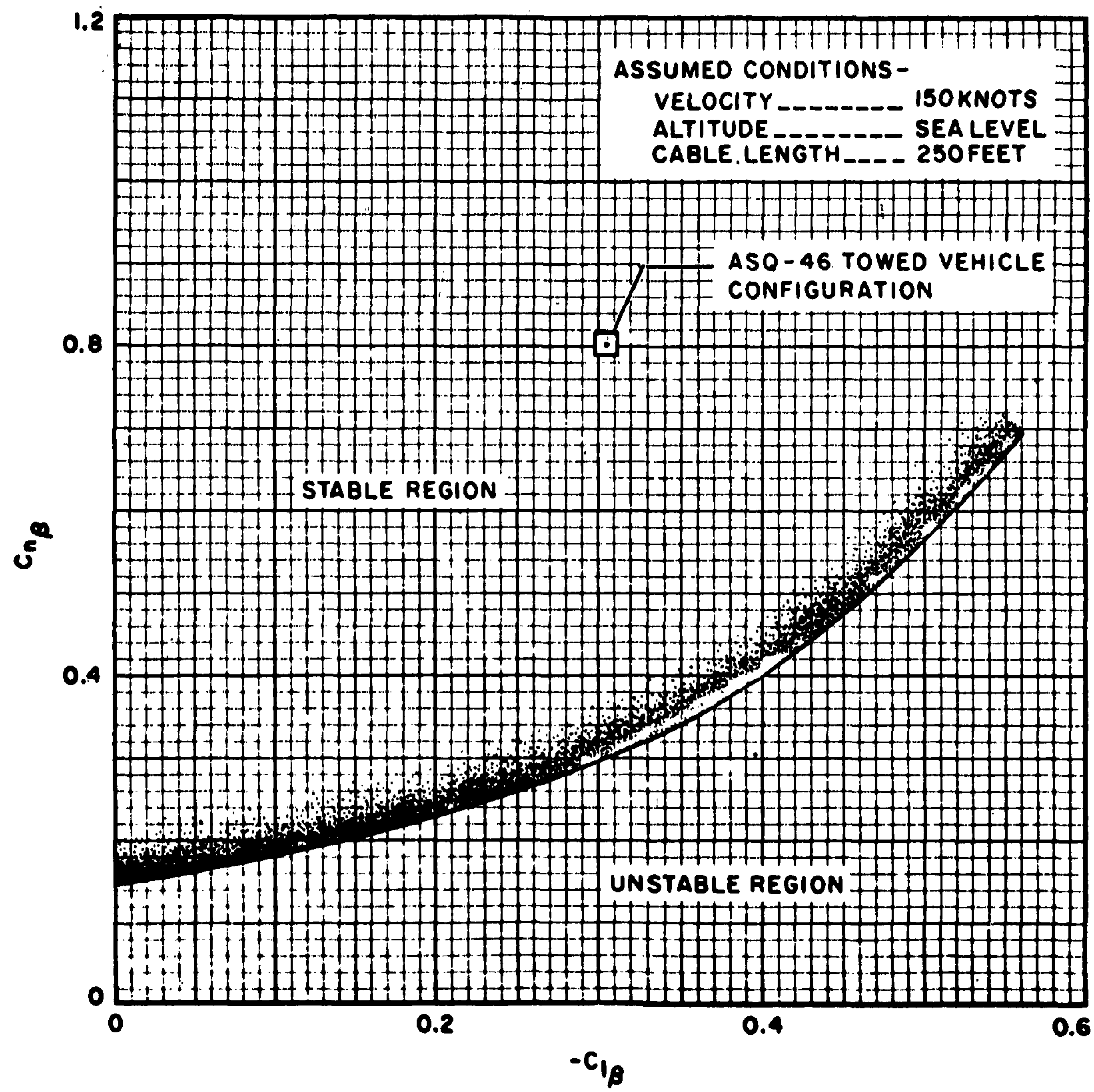

FIGURE 6 - Lateral Stability Boundary (C_{n_β} vs C_{l_β})

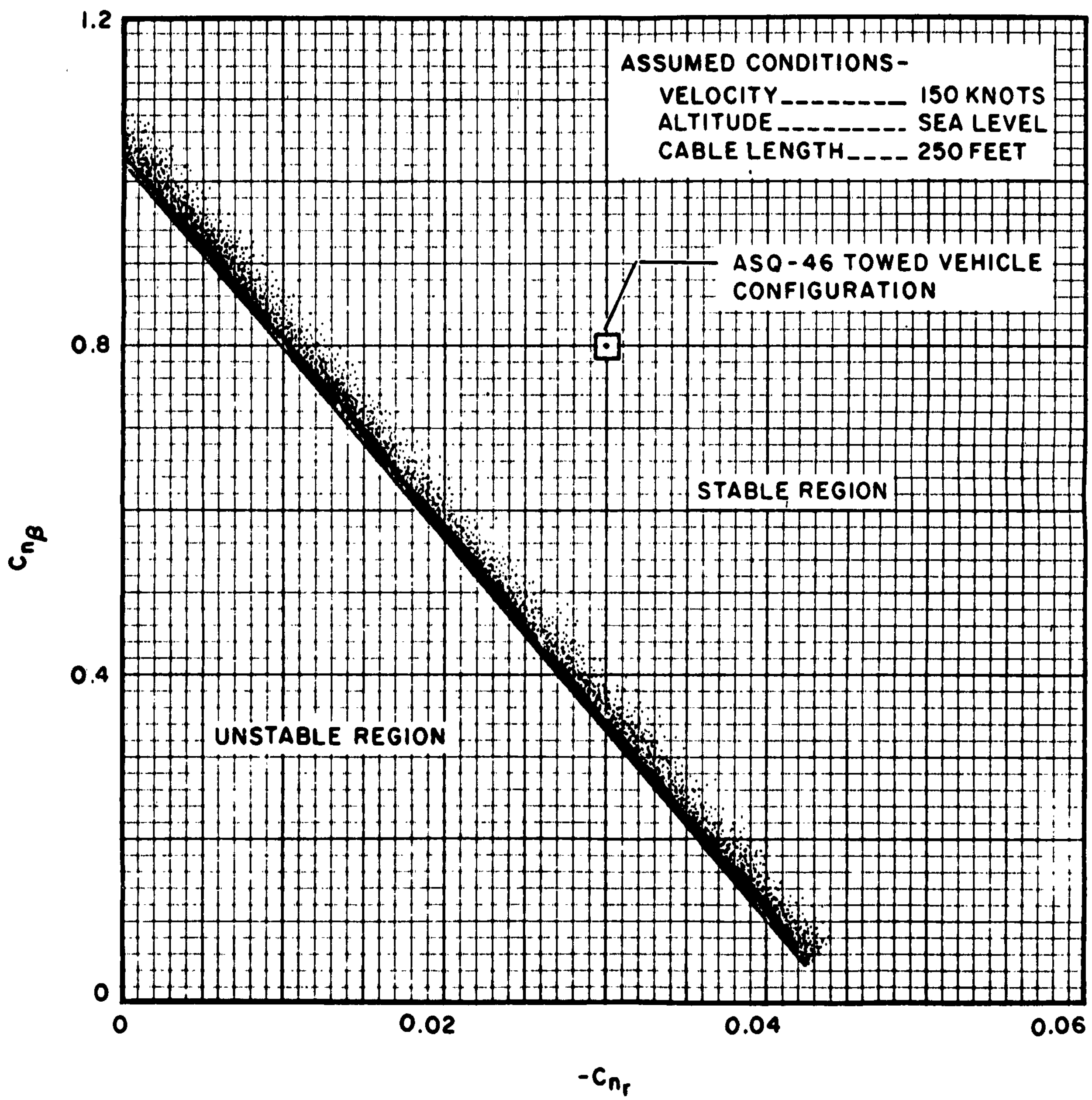

FIGURE 7 - Lateral Stability Boundary (C_{n_β} vs C_{n_r})

D I S T R I B U T I O N   L I S T

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